Transactions of The Academy of Science of St. Louis.

VOL. XI. No. 7.

THE PROGRESS MADE IN BOTANY DURING THE NINETEENTH CENTURY.

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Issued November 26, 1901.

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WHAT BOTANY STOOD FOR AT THE BEGINNING OF THE CENTURY.

At the beginning of the Nineteenth Century about 25,000 species of plants had been described, and, though considerable use had long been made of other species which at the beginning of the century were unclassified and unnamed by botanists, the number of these were relatively small, so that the entire knowledge of botany, economic as well as scientific, and in all of its branches, was practically confined to the limited number of species mentioned. This knowledge consisted in a recognition of their specific differences and the rather superficial affinities and relationship deduced from these in a great but often hopelessly scattered and frequently erroneous literature, and in popular acquaintance with their useful properties — particularly their medicinal virtues, and a general blocking out of their anatomy and physiology,— to no small extent a matter of subjective opinion.

SYSTEMATIC BOTANY.

About the middle of the preceding century, Linnaeus had elaborated a workable, if artificial, system of classification, which, with brief but sharp diagnoses, made it reasonably easy to ascertain whether a given species of plant in hand had been previously described or was new to science; and as he had combined with this the very simple expedient of referring to the several species by latinized binomials instead of by descriptive phrases, the naming and describing of species has proved not only one of the most necessary but also one of the easiest and most popular branches of this as well as of the related biologic science, zoology, during the century just closed.

* An address delivered before The Academy of Science of St. Louis, November 8, 1901.

Linnaeus himself, in 1771, admitted 8551 species of plants of which more than nine-tenths belong to the most obvious and grossly marked group, the flowering plants, which, with the ferns, still represent the field of botany for uneducated persons. The rapidity of progress in differentiating unrecognized species and characterizing such as had remained unobserved is shown by the increase of Linnaeus's scant 9,000 to some 70,000 before the first quarter of the Nineteenth Century had been passed, and, largely because of territorial exploration, the next half century produced even greater results and the phenomenal interest in the interior of Africa evinced during the closing decade of the century is to-day bearing like fruit. With this activity in collecting and naming plants came inevitably a progressive interest in the more and more difficult and minute flowerless plants, so that through the studies of Presl, Milde, the Hookers and others on ferns and their allies, of Schimper, Leitgeb and others on mosses and liverworts, of Agardh, Kuetzing, Harvey, Thuret and Bornet on algae, of Fries, Persoon, and the Tulasnes on fungi, and of Acharius and Nylander on lichens, the proportion of cryptogams to flowering plants gradually advanced, notwithstanding a very great increase in the latter, until at about the close of the third quarter of the century approximately one-fourth of the 125,000 species then known were cryptograms. Then came a much increased activity in the study of these minuter plants, partly from the concentration on them of study no longer believed to be necessary for the flowering plants of the more accessible parts of the world, these having been fairly satisfactorily disposed of on the grosser or so-called Linnaean ideas of specific limitation, and partly because of DeBary's studies of parasitism and a recognition that many of the diseases of cultivated plants are caused by fungi, the differentiation of which then became important from an economic as well as a systematic point of view. At the close of the century not far from 180,000 species of plants were known, of which some 75,000, or more than the total number of species known in all groups at the end of the first quarter of the century, are cryptogams. The last decade, however, has witnessed a proportionally greater increase in phanerogamic

species than that marking the immediately preceding decades, because of the geographic exploration already referred to, and still more because of a growing change in the scale of specific differentials which has resulted in the segregation of many forms which under the older views passed for at the most varieties of polymorphic or variable species. The genera *Rubus* and *Hieracium*, in Europe, and *Viola*, *Sisyrinchium* and *Crataegus*, in our own country, well illustrate my meaning.

Just as the descriptive manuals of Linnaeus, and the editions of them published after his death by Schultz, Willdenow and others, facilitated and stimulated the accumulation of hitherto unrecognized species at the beginning of the century, its progress throughout has been recorded and accelerated by the publication of later works of the same general character and purpose. For the flowering plants, some of the most noteworthy of such general descriptive works are the incomplete Prodromus and Monographiae of the De Candolles, the numerous revisions of genera and families in Engler's Jahrbücher and the Journal of the Linnean Society, and the comprehensive Index Kewensis prepared by Mr. Jackson under a provision made in Darwin's will; and no account of this aspect of the science would be at all complete without reference to the books and journals devoted to the illustration of plants, foremost among which stands the Botanical Magazine, which, founded by Curtis in 1790, has been continued without interruption, and at the end of 1900 contained 7751 colored plates, mostly illustrative of plants of decorative value. For Pteridophytes, the manuals of Hooker and Baker have been most helpful. Bridel, Schimper and Warnstorf stand out prominent among those who have published comprehensive manuals of the Bryophytes, while the enormous Sylloge Fungorum of Saccardo and the as yet incomplete Sylloge Algarum of DeToni have made accessible the myriads of scattered descriptions of species belonging to these groups of the lower cryptogams.

SYSTEMS OF CLASSIFICATION.

The simplicity of Linnaeus's classification of flowering plants has been mentioned. The popular handbooks even of

our own flora, up to a point somewhat after the middle of the century, were based on this system, which, when the purpose of the student was to find the name of a plant, has scarcely been equaled by any other; yet it had one very great defect, in that plants which were obviously related might come to stand far apart in it, so that the suggestion of this relationship would be lost on the user of a book in which it was followed. Even before the close of the preceding century, efforts had been turned to the arrangement of a natural sequence of the higher groups of plants, so that those which possess a number of important and correlated characters in common might be brought together, leaving the tracing of any given species to its place in the system for a quite independent artificial key, — the Linnean, for instance, or some other specially fancied by the writer or suited to his purposes. To the Jussieus the inception of this movement in a modern sense is due, and the elder DeCandolle stands out prominently among those who amplified and bettered it; and yet the success of these earlier seekers for a natural system was but partial, and in the summation of their conclusions, as exemplified, for instance, in the great Genera Plantarum of Bentham and Sir Joseph Hooker, though many of the resultant groups, even no higher than orders, possess a very puzzling complexity because of the insertion of aberrants, there still remain many, as, for instance, a large part of those constituting the so-called Apetalae, which are obviously little more than makeshifts, loose-jointed in themselves and with scarce concealed affiliations of the most diverse kinds. As early as the middle of the century, by his comparative developmental studies of the gymnosperms and higher cryptogams, Hofmeister laid the foundations of a more rational system, which, largely through the labors of Alexander Braun and Eichler, culminated in the phylogenetic system of Engler, which marks the close of the century.

Somewhat comparable needs and advances have marked the knowledge of the cryptogams. The ferns and their allies early differentiated themselves from the remainder of this great second group of Linnaeus, and the mosses and liverworts as quickly came to be recognized as forming another

distinct group of primary importance in any natural classification, the researches of Hofmeister contributing largely to this result; but even to-day, convenience of treatment, if no other reason, causes specialists to write commonly on either algae, fungi or lichens, according to the group of thallophytes they may be studying. And yet the beginning of better things has been made, for DeBary's suggestion and Schwendener's morphological demonstration that lichens are in reality only certain fungi with enslaved or commensal algae as an integral and usually necessary part of their organization marks the close of the third quarter of the century, and in the concluding quarter various efforts have been made at a classification of the thallophytes on more scientific grounds than the pressence or absence in them of chromophyll-bearing cells or tissues. Though the goal may not yet have been reached, these efforts are full of promise for success in the century that is now on the calendar.

EVOLUTION AND CLASSIFICATION.

It was in the first decade of the century that Lamarck, following a line of thought that had caused men long before his time to speculate on the varied forms of nature, attempted to show how environment, use and disuse of parts, and similar natural factors might have brought about modifications leading to the origin of new species from ancestors otherwise characterized; and the year 1858 will always stand out in prominence in the history of biology because of the simultaneous presentation in that year of almost identical explanations of the manner in which natural selection, or the survival of the fittest in life's struggle, might and of necessity must lead to the repeopling of a given territory by new forms descended from those pre-existing, provided, in the progress of time, the conditions of life were changeful and variations were present in offspring, as compared with one another and their parents, — as was well known to be the case. Darwin and Wallace, the authors of these first papers, did not go to the bottom of their great subject, and the last word on it is far from having been said yet, but the theory of organic evolution may be regarded to-day as an axiom on which most philosophical analyses of biology rest as a footing course.

Closely connected with the changing conceptions as to the origin and fixity of species, was a much increased interest in such evidence concerning the plants of the past as was afforded by their fossil remains, and, largely through the work of Brongniart, Goeppert, Heer, the elder Schimper, von Ettingshausen, Saporta and Solms Laubach, and Dawson, Newberry, and Lesquereux in this country, paleobotany has assumed, in the last fifty years, a position of no small importance.

Partly because of the same reasons, the geographical distribution of plants and the influences controlling widespread or restricted occurrence in the case of individual genera or species has also assumed an importance in recent years not formerly recognized for it, and on the foundation laid by DeCandolle, Humboldt and Martius, Grisebach, Engler, Drude and the younger Schimper have grounded a line of botanical research in which morphologists, systematists and evolutionists are alike interested.

With the change in the world's view of the fixity of species, and of their several and independent origin in their present form, came new and somewhat differently conceived efforts to group plants in a natural system, the ultimate object being virtually the production of a classification which should represent descent relationship as well as organic or morphological affinity, and which, in a word, should present the family tree of any individual group or species, —to the primitive animal and vegetable main divisions of which Haeckel in particular has given attention. A comparative glance at the Genera Plantarum of Bentham and Hooker, the synopses of Van Tieghem and Warming, and the still incomplete Pflanzenfamilien of Engler and Prantl will show how great have been the changes wrought in systems of classification by the introduction of these later considerations and motives. Free to read heredity and atavism into the explanation of aberrant minor characters, rudiments and vestiges, these men have often found in the minuter details of anatomy, reproduction and development most surprising indications of affinity between superficially and externally dissimilar groups. That they are not at one in their conclusions, indicates that the Twentieth

Century may regard the preparation of a truly natural system even of the higher plants as a part of its legitimate and necessary work, and it may well be that even though this task be accomplished, a like result among the lower cryptogams will be reserved for the next century. At any rate, although DeBary and others have contributed to a rational comparison of the larger groups of thallophytes, a glance at the sytematic memoirs relating to the fungi and algae shows a most obvious if convenient artificialty in their classification.

MORPHOLOGY AND ANATOMY.

Some years since, I saw with much interest a palm in the Botanical Garden of Padua on which, toward the end of the Eighteenth Century, the great poet Goethe made some of the observations which led to a formulation of his theory of metamorphosis in the parts of plants,— a theory which, in the first half of the century just closed, DeCandolle, our own Engelmann and others put upon a more scientific basis as a fundamental idea in plant morphology. Toward the middle of the century, the superficial indications afforded by position, gradation and malformation of parts were much strengthened by embryological and developmental studies, and it was about this time that the details of cellular structure, grossly known for a couple of centuries, were brought out by Robert Brown and Schleiden, the latter of whom stated in another form for plants the general fact of the origin of every cell from a previous cell, succinctly expressed by the now venerable Virchow, whose eightieth birthday has recently been celebrated in this country as well as in his native land; for by this time these structures had come to be recognized as the seat of vital manifestations through their protoplasm, which, discovered and named by von Mohl, and the nuclear differentiation of which was observed by Robert Brown in 1835, and which was shown to be similar in animals and plants by Cohn in 1850, Huxley has so happily designated as the physical basis of life.

Though external morphology and anatomy, the latter even in some of its minuter details, had come down from the past, both may be said to have been made a part of science in the Nineteenth Century, and the fact that homologous members

may serve the most diverse organic purpose, that sometimes analagous organs, like the leaf of the moss and that of the flowering plant, cannot be morphologically compared, since they are parts of fundamentally unlike plant bodies, shown primarily by Hofmeister's discovery of alternating generations in 1851 (one representing the gametophyte and the other the sporophyte of beings with alternating sexual and non-sexual generations), and that cells, cellular tissues, and systems of such tissues show a similar and comparable pliability in their adaptation to physiological function, as Haberland and others have made clearly evident, with many other facts of equal importance for a right understanding of nature, may be credited in large part to the last half, and, as to much of their detail, to the last quarter, of the century. Indeed, the consideration of tissues from a proper morphological point of view dates practically from Hanstein's studies in 1868, and their rational terminology was established by DeBary nearly a decade later.

Though initially wrong, Schleiden as early as 1837 laid the foundation of embryology in botany, and the organogenetic studies of Hofmeister, Payer, Sachs and Goebel will always stand as classics in the application of the developmental line of research to the progressively formed grosser parts of more mature plants.

PHYSIOLOGY.

Physiology, either of animals or plants, could scarcely have become a science before the determination of the grosser chemical composition of the atmosphere, which, made by the chemist Priestley toward the end of the Eighteenth Century, was quickly followed up by him, Ingen-Housz, de Saussure, Hales and numerous others, with the result of showing that a very considerable part of the organic matter of which plants consist is derived from the carbon dioxide of the atmosphere, which is fixed in carbohydrate form in the green parts of plants under the influence of light; and the studies of Draper and Wilhelm Engelmann stand out in prominence as contributing to our present knowledge that certain wave-lengths of sunlight, when passing through the chlorophyll or comparable pigments of plants, disappear as light, and are

converted into chemical or physical energy, which, under the guidance of the living protoplasm of the cells, is utilized for the breaking down of carbon dioxide and water, their elements being then recombined into the organic products referred to, the most usually recognizable of which is starch. An attendant liberation of oxygen, constituting, with the abstraction of carbon dioxide, a purification of the air, so far as the needs of animals are concerned, was made known shortly before the century began, but it is to Saussure, at its very beginning, that the connection of this with actual plant nutrition is due, and it was he, too, who gave the first clear demonstration that the remainder of plant food is derived from the soil. A detailed study of this subject, as well as of the metabolism or elaboration and transmutation that food undergoes in the plant in its various nutritive and storage processes, occupied particularly Sachs during the third quarter, and Pfeffer during the last quarter of the century, Pfeffer's ingenious investigation of the osmotic action of root hairs being particularly interesting in connection with the physical problems of the absorption of crude materials and the retention of organic products in the self-same organ. The last half of the century has also produced the demonstration, on a large scale in the field experiments of Gilbert and Lawes, and on a smaller scale, but under more rigid control, in the laboratories of numerous investigators, of the fact that while free atmospheric nitrogen is not available for the nutrition of higher plants, which therefore as a rule require for their proper support an abundance of available nitrogen supplied to the roots in the form of nitrates, nitrites, etc., the Leguminosae as a class make use of large quantities of this atmospheric nitrogen, not, indeed, in its free form directly, but through the intervention of certain of the lowest fungi which inhabit their roots as parasites, but, having the power of assimilating nitrogen in forms in which it is not usable by the higher plants, contribute to the latter enough of the product of their own activity to more than compensate for whatever injury they may cause by their parasitic invasion of the tissues of the host. Indeed, pure cultures of these pseudo-parasites are on the market, under the name of nitragin, for the inoc-

ulation of new soil when sown to clover and other leguminous crops, though it must be added that the practical value of this inoculation is thrown in considerable doubt by recently made laboratory experimental tests.

PROTOPLASM.

Doubtless the most important of all discoveries in physiology is that of protoplasm as the living working part of both plants and animals, in the early phases of which von Mohl, Robert Brown, Naegeli and Cohn played a prominent part. Studies on this substance, its physical and chemical properties, and its activity, have occupied many of the best chemical, physical and biological investigators of the last half of the century, and are destined to be the keystone of physiological attainments in the century we are now entering upon.

Though sex in the flowering plants was known long before the century opened, to the extent that the co-operation of stamen and pistil, and even the transfer of pollen from the former to the latter, was recognized as necessary for the production of fertile seed,— a fact, indeed, which Linnaeus indicated and even amplified in his designation of the groups which he called phanerogams and cryptogams,— it was not until 1823 that Amici observed the growth of the pollen tube to the ovule, and real fertilization, the union of protoplasmic structures, was not demonstrated until the close of another quarter of a century, when Hofmeister and Pringsheim at intervals of a few years described it respectively for some of the higher and lower cryptogams.

The greatest advance in protoplasmic study was doubtless made possible by Strasburger's introduction, in 1875, of methods for fixing protoplasmic structures in certain desired states of their transformations, by the use of killing and hardening fluids, and the addition a few years later of differential staining processes, as a result of which, largely through his efforts and those of his pupils, the minutiae of both cell division and cell union have been carried to a wonderful detail,— perhaps the least expected result of which is the closing discovery of the century of an unexplained double fertilization in the case of the flowering plants, by which the endosperm is formed as well as the embryo.

How protoplasm carries "life," the nature of the reactions it shows to stimuli of various kinds, causing it to work, to change, to rest, to die, how it is moved to vary in the forms of tissues and organs over the construction of which it presides, how it transmits characters of form and action from parent to offspring and reverts now and then to ancestral structures and traits in both animals and plants, are scarce more than question marks on an otherwise clean page spread out before the Twentieth Century, and it is not possible yet to say whether they will receive their answer soon or always remain unanswered.

ECOLOGY.

One of the most popular lines of physiological work to-day concerns itself with special modifications and activities connected with local environment and what may be called the personal or individual needs of plants, in contrast with their needs as a class. This is called biology by some and ecology by others.

Just before the end of the Eighteenth Century, a German, Sprengel, observed a few hairs springing from the base of the petals of a wild geranium, and, though he did not share the impersonal teleological views that prevail to-day, he believed that these hairs existed for a purpose, which he undertook to find out. Under them he found glands secreting a sweet fluid, nectar, which he saw was sheltered by them, but the nectar was a further puzzle. Bees came to the flowers as he watched, and removed the nectar, which the glands had secreted and the hairs protected for them, and the question seemed answered; for an idea, somewhat prevalent even yet, that everything exists for the good of something else, — generally higher in the scale than itself, — was commonly held in his day. Further observation, however, showed him that the bees became dusted with pollen and that they unconsciously transferred some of this to the stigmas of the flowers, while rifling them of their sweets, and that this transfer, long known as necessary in some manner for fertilization and the quickening of the germ, could not otherwise take place except by remote chance. Then he examined many other kinds of flowers, and reached the broad conclusion that nectar

in these organs exists for the sole purpose of attracting to them insects, sometimes of one, sometimes of another kind (for which it is protected from rain and dew and commonly from other classes of insects, and to which its presence is made known by odor and color, and its position by grooves and other guiding mechanism and by variegation in the coloring), which, while serving their own purposes, ensure the pollination of some flowers which might attain the same end directly as well of others which from some seeming freak of nature mature stamens and pistils at different times or even have them separated in different flowers, — sometimes, even, on different individuals. A half century later, Mr. Darwin, seeing in floral forms, colors and odors something more than means of overcoming chance defects in plan or development, showed not only the general accuracy of Sprengel's conclusions as illustrated by a host of other cases, but that they might be carried a step further, by stating the purpose of the structural and functional peculiarities in question to be the effecting of cross fertilization. Then he set to work to prove, by a long-continued series of experiments, whether or not this is connected with a gain to the offspring resulting from such crosses, and we cannot question the resulting conclusion that it is. Indeed it may be asked if any axiom is more important to an understanding of the evolutionary adaptation of species to changing environment than the obvious conclusion that sex, and particularly the partition of the sexes with secondary provisions of the most varied kinds for their functional union, is a most potent factor for the introduction of variation within helpful limits, on which natural selection may build with the current of the times, as well as for the direct betterment of the offspring.

How dissemination is effected, and the structures connected with it; how plants may climb to the light and air with a minimum expenditure of material, over their more robust competitors when the latter have reached their own limit in the occupation of the soil; how they may feed upon each other and upon animals; how they may extend into deserts and the salt sea: — these and many other questions show the range of ecology as it is now occupying alike physiologists,

morphologists and systematists, and, while much remains to be done, its blocking out is likely to stand as one of the more important achievements of the century just closed.

APPLIED BOTANY.

Hand in hand with the advance of pure botany, and largely dependent upon it, have gone at least as great advances in the application of ascertained facts; and the best agricultural practice of to-day, as exemplified in the intelligent use of fertilizers, the rotation of crops, etc., is conformed to the teachings of vegetable physiology, while the knowledge of the plasticity of plants has made each of the later decades the recipient of numerous improved races and varieties of cultivated species. To-day, among the more pliable forms, within certain limits that cannot yet be overstepped, new varieties suited to special needs are selected and bred by men like Burbank with surprising rapidity and accuracy, almost to drawing and specification, because of the practical application of the knowledge that plants are plastic under environment and selection.

The details of other contributions of botanical science to human needs are of no less interest. Modern brewing is carried on scientifically, as a result of the fermentation studies of Schwann and Pasteur and the cultural investigations of Hansen, a yeast being employed which has developed from a single cell of known pedigree and properties. Citric acid and vinegar are produced with equal certainty if less complexity of manipulation, and the method of pure cultures of the necessary ferments is coming into considerable use in the ripening of cream for butter and of cheese.

Perhaps the most markedly useful application of the botanical knowledge of the century is in the field of medicine. In the early part of the century, the physician was of necessity a botanist, and indeed many of the botanists whose names appear in this account were physicians by training. From the Middle Ages he had the knowledge of physic that characterizes primitive man everywhere to-day, and this had gradually come to represent a pseudo-science of therapy which he practiced by diagnosis, prescription and exhibition,— if I may

borrow a word. But the century just closed has seen a differentiation of pharmacy from medicine which has not only greatly simplified the materia medica through its more careful investigation, but has given the physician more freedom to follow out his own field, so that to-day, while he must know experimentally the physiological action of more plants than his predecessors actually used, he need not ordinarily know more of these plants than that their active principles, in sulphates, fluid extracts and the like are commercially procurable in definite degrees of assimilability and concentration, though his final trials have not been lessened thereby.

The century will forever stand as that in the last third of which the germ causation of disease was made known, and the names of Pasteur, Koch and Lister are inseparably connected with this great addition to knowledge, which,— since the germs of disease are for the most part bacteria, that, though of simple and aberrant structure, are commonly classed with plants,— must be counted among the achievements of botany. Sanitation and surgery have both been put on an entirely new footing by this recognition that the minutest organisms yet known are responsible for many of the most dreaded pests, so that the exclusion or elimination of germs, and the use of their own products,— either direct or by animal reaction in the form of serums,— in therapy, form today the surest safeguard against infectious disease, the occurrence of which may soon be regarded as almost a stigma on civilization.

The century just closed has witnessed an almost equal advance in knowledge of the causation of the diseases of plants themselves. Rusts, smuts and mildews are no longer looked upon as exanthemata, but the fruits of parasitic fungi, which, more than is the case with the parasites of animals, are of the less minute and therefore more easily seen and controlled groups,— though plants are also subject to a few bacterial diseases. Much has been done in the way of prophylaxis, and something in the way of germicide therapy, in this field, and the foundations of a true science of plant pathology based upon distorted physiological processes due to improper environment, food and the like, or to the ferments secreted by

parasites or the chemical alterations which these induce in the affected plants, may be said to have been laid in the closing days of the century by Professor Marshall Ward.

POPULARIZATION AND PUBLICATION.

The development of any department of science is closely connected with its power of interesting men. The present tendency of this interest is more and more commercial and economic, though it should be said at the same time that no earlier period has witnessed a higher development of interest in the purely abstract problems of science.

The lucid, terse Latin of Linnaeus did much to popularize the botany of his time, and for the century just closed full credit should not be withheld from those whose writings fostered and spread an interest in their science. Schleiden, Lindley, Willkomm, Gray, Darwin, Kerner von Marilaun, Gibson and Lubbock have shown pre-eminent ability to perpetuate the old and awaken new interests. Too great value can scarcely be attributed further to the scientific stimulus and opportunity due to the publication of such comprehensive class-books as the general text-book of Sachs, the Comparative Anatomy of DeBary, the physiological manuals of Sachs and Pfeffer, the pollination works of Herman Mueller and the dissemination treatises of Haberland, all of them original contributions to science as well as adaptations of its results to the purpose of the teacher; and the abridgments, local adaptations, popularizations and imitations of these products of leaders, reaching and being comprehended by a larger audience, may perhaps have done even more toward fanning into flame the first spark of enthusiasm and desire for research.

Quite as noteworthy is the advance in educational and instructional methods, and appliances other than books. Up to the middle of the century, instruction in botany was confined to more or less perfunctory lecture courses, and the pupil who would become an investigator was obliged to work out his own salvation, or was permitted as a special favor the privilege of association with a master. The opening of a botanical laboratory at the Univerity of Freiburg, by DeBary, in 1858, marks an epoch. It is a poor college to-day, as the

equipment of colleges now goes, which has not a better laboratory and a better equipped one than was DeBary's. With the introduction of laboratory work came the training, in the laboratories, of laboratory teachers to spread the leaven, not only by repeating the process but by publishing in detail their methods for the benefit of others who could not work under them. It would be impossible to overstate our debt to Huxley and Martin's Biology and the many guides of which it was the precursor, to Strasburger's Practicum, the various treatises on microscopic technique and microchemistry, and the increasing number of physiological handbooks which have grown out of Detmer's original. That the botanical world has to-day not only the attainments of its predecessors, but as a regular institution these facilities which did not formerly exist for the performance of work, may perhaps be regarded as affording ground for the hope that the century upon which we have now entered will as greatly surpass in achievement the one just closed as the latter did all of its predecessors.

BOTANY IN THE UNITED STATES.

Though epitomized in the preceding general survey of the field, the progress in our country of what has been called the amiable science interests us so directly that I may briefly touch on it in conclusion.

Systematic phanerogamic botany, early advanced through the labors of Nuttall, Pursh, the Michaux, Elliott and others, made rapid strides about the middle of the century, when Torrey and Gray undertook the publication of their Flora, — unfortunately never completed, partly because of the wealth of new material brought to its authors as a result of the extensive explorations of our western territory undertaken by the Government. Without mentioning others who have greatly contributed to its advancement in recent years, I may say that Gray's Manual, Chapman's Flora of the Southern States, Watson's contributions to western botany, Coulter's Rocky Mountain Botany, and the masterly revisions of critical groups by Gray, Watson and Engelmann, have brought a knowledge of our plants within the reach alike of investigator and amateur; while few countries possess a local flora comparable with that of Britton and Brown,

and the great Silva of Sargent, now nearly completed, stands quite alone. Eaton and Engelmann laid a good foundation for the further study of pteridophytes, which Davenport, Robinson, Underwood and others have later brought to the hands of every working botanist. Through the work of Sullivant, Lesquereux, James, Austin, Barnes and Underwood, the bryophytes have been similarly put within easy reach, though the current work of Mrs. Britton, Evans, Renauld and Cardot shows that even more than with the superior groups, the field for systematic research is here still open. By the publications of Harvey, Farlow, Collins and others on marine forms, and of Wood, Wolle and others on those of fresh water, our algae have been exceptionally well blocked out. Tuckermann, Willey and Williams have brought the lichens together; and though less advanced than either of the others, the great group of fungi, because of its size, has been the subject of more actual work than all of the remaining cryptogams, and the names of Berkeley, an Enlishman, and of Schweinitz, Curtis, Ravenel, Farlow, Thaxter, Peck and Ellis stand out prominent among those who have contributed to its lasting literature. Like the great English botanists, Americans have been closer adherents to the DeCandolle classification of flowering plants than to the later French and German systems until very recently; but the disposition of to-day is strongly toward the latter. I may mention, in passing, that the new plantations of the Missouri Botanical Garden will be twofold, — one portion illustrating the now familiar but rapidly passing French-English system, while another and greater part will follow the general lines of the present German school.

Americans were quick to take up the Darwinian ideas of evolution, — none quicker than the great botanist Asa Gray, and it may not be going too far if I say that nowhere in the world has horticultural advantage been more fully taken of their teaching than in America, Bailey's varied work in this field being particularly mentionable.

Though morphological teachings were prevalent in the middle part of the century, as a research subject morphology has been confined to the later years, during which, in connection

with more precise anatomical studies, it has contributed to an important if not very extensive literature, — largely, it must be confessed, resting upon the studies of German-trained students.

Vegetable physiology, as a subject for serious work in this country, can scarcely be traced back of the last quarter of the century, except for the much earlier isolated studies of Draper; but to-day the force of several well-equipped laboratories, and numerous isolated workers, are probing the difficult problems the solution of which could not be compassed in the century just closed. Nowhere has that phase of physiological work known as bionomics or ecology been more eagerly taken up than in this country, and, beginning with Dr. Gray, a number of workers have enlarged our knowledge of the pollination, dissemination and germination of plants, while the last few years have witnessed a widespread and growing interest in the vegetative relations of plants to their surroundings, and in the manner in which, as individuals and communities, they compete for a foothold on the earth.

Without going into details, I may say that America leads the world in the attention given to botanical (as other) research relating to agriculture and horticulture, and no small part of the recent progress in this field has come from our Government and State laboratories and experiment stations.

In conclusion, as, perhaps, the greatest advance in botany made in this country during the century, I may note the increase and improvement in means and methods for instruction. The great strides made in this direction by the Germans at the close of the Franco-Prussian war, and the prestige of DeBary, Sachs, Pfeffer and Strasburger in their Universities, stimulated and attracted Americans to such an extent that to-day no country, aside from Germany, offers so many, so good, or so varied opportunities for training in scientific botany as we possess in the United States, and a rich fruition may be confidently expected in the century on which we have now entered.

Issued November 26, 1901.

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